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ABSTRACT

The ability of 3-, 4-, and 5-year-old children to infer the position of an object in a room from information contained on a map was assessed under five conditions: (1) map aligned inside the room (the pretest); (2) map aligned outside the room; (3) map rotated 180 degrees inside the room; (4) map rotated 180 degrees outside the room; (5) map held vertically outside the room. The results indicated that rudimentary map-reading, as indicated by the pretest, begins between 3 and 4 years of age, but that the ability to compensate for a rotated map does not develop until age 5. The position of the map inside or outside of the room did not affect performance in either the aligned or rotated conditions, with the exception that fewer egocentric errors were made in the rotated-outside condition than in the rotated-inside condition. The relative ineffectiveness of the position variable was interpreted as evidence that young children are capable of generating a mediating mental representation of the map although they may be unable to mentally manipulate it. The vertically held map was easily interpreted by most children who succeeded on the pretest. All the results are discussed in relation to spatial development in general and a three-component model of map-reading in particular. (Author/CM)

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Developmental Changes in Map-Reading Skills[1]

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Abstract

The ability of 3-, 4-, and 5-year-old children to infer the position of an object in a room from information contained on a map was assessed under 5 conditions: a) map aligned inside the room (the pretest); b) map aligned outside the room; c) map rotated 180° inside the room; d) map rotated 180° outside the room; e) map held vertically outside the room. The results indicated that rudimentary map-reading, as indicated by the pretest, begins between 3 and 4 years of age, but that the ability to compensate for a rotated map does not develop till age 5. The position of the map inside or outside of the room did not affect performance in either the aligned or rotated conditions, with the exception that fewer egocentric errors were made in the rotated-outside condition than in the rotated-inside condition. The relative ineffectiveness of the position variable was interpreted as evidence that young children are capable of generating a mediating mental representation of the map although they may be unable to mentally manipulate it. The vertically held map was easily interpreted by most children who succeeded on the pretest. All the results are discussed in relation to spatial development in general and a 3 component model of map-reading in particular.

Developmental Changes in Map-reading Skills

The act of using a map to find one's way is hardly considered an extraordinary cognitive feat, until one finds oneself in the position of the frustrated and bewildered traveler, who, with the aid of a road map, still manages to get hopelessly lost. Only then does one give some thought to the complex issues involved in map-reading, and, as with so many other phenomena, it is often the most ordinary that deserves a closer look. From a developmental perspective map-reading is particularly worthy of scrutiny, representing as it does, a prime example of the symbolic or semiotic function at work. Here we see well-illustrated the process of requiring symbols to substitute for, to "represent," sets of concrete objects in the world. More than that, the map involves a representation of the relationships among these objects, much as the function words in language represent the relations among objects symbolized by nouns. We should be able to use, therefore, the development of map-reading abilities as a means of acquiring additional insight into the development of fundamental cognitive capacities.

A second factor which necessitates a closer look at the development of mapping skills is the fact that in many investigations of the development of spatial concepts such skills have been relied on to provide a means of assessing the nature of the subject's internal cognitive representation of space. Sketch maps, for example, have long been a primary dependent measure in studies of cognitive mapping in both adults (e.g., Appleyard, 1970; Lynch, 1960) and children (e.g., Ladd, 1970; Shemyakin, 1962). Furthermore, when common sense has indicated that the young age of the subjects rules out a measure at this level of abstraction, researchers, rather than

abandoning mapping completely, have endeavored to concretize the mapping task through the substitution of 3-dimensional models of the spaces (e.g., Siegel & Schadler, 1977; Piaget, Inhelder, & Szeminska, 1960; Pick, Acredolo, & Gronseth, Note 1). All too often in studies such as these the ability to map is assumed, and any failures in the resulting maps are attributed to inadequacies in the underlying representation, when in reality the problem may be in the translation of that representation to the 2- or 3-dimensional model. Before such conclusions can be drawn it is crucial that developmental psychologists acquire more information about the development of mapping skills themselves. Consequently, the present experiment was designed to provide some initial data on one aspect of mapping: map-reading.

For the purposes of the present discussion map-reading is defined as the ability to infer information about a three-dimensional, large-scale space from a two- or three-dimensional small-scale representation of the space. The establishment and utilization of such an association between map and environment can be viewed as the product of at least three distinct cognitive processes, each of which may prove to have a separate developmental history. The first of these processes is the interpretation of two-dimensional cartographic or pictographic symbols and the understanding that they refer to real three-dimensional counterparts. Blaut, McCleary, and Blaut (1970) refer to this as the "semantic interpretation" component. Clearly the development of this component will vary with the degree of abstraction and representational complexity of the map. The second cognitive process involves the formation of a mental representation of the map, that is, a kind of "cognitive map," to serve as the associative link between map and space, particularly when the

map and the space are not viewed together. The third process, completing the link, is the projection or superimposition of the mental representation of the map upon the environment itself through the use of landmarks and systems of reference, thus facilitating orientation within that environment. Flexibility is a key word here since a good map-reader should be able to adjust from a vertical perspective to the horizontal perspective from which the surrounding environment is usually viewed, while at the same time preserving the integrity of the features and the spatial relations among them. He or she should also be able to compensate for rotation of the map relative to the space. Returning to the still bewildered traveler with the road map in hand, his or her failure to successfully use a map for orientation within the greater environment it represents may be attributable to a cognitive deficit in any of the three processes.

Surprisingly little is known about the development of these abilities beyond the fact that it takes time to learn cartographic symbols and conventions, the first of the three components discussed above (Rushdoony, 1968). One of the few recent studies that has addressed those issues at all is a study by Blaut, McClearly, and Blaut (1970) in which 5-, 6-, and 7-year-olds were shown an aerial photograph of a community. The children's ability to identify features such as houses, roads, cars, and trees demonstrated, according to Blaut et al., their cognitive ability to transpose perspective and scale from their actual environmental experiences to a perspective they had never before observed. In a second phase of the study the children made tracings of the photograph and then solved navigational problems by indicating on these "maps" appropriate routes between various features. The authors conclude from the children's successes that "preliterate children of school-

entering age can... engage in a real, if primitive, form of map-reading, map-making, and map use" (p. 346). The question remains, however, as to whether such behavior actually does constitute even a primitive form of map-reading, lacking as it does any requirement for inferences from the two-dimensional map to the three-dimensional space represented. Clearly, according to the definition of map-reading suggested previously it does not. Blaut et al. may have demonstrated the existence in these children of the first component, and perhaps even the second, but certainly not the third.

Some indirect information about this third component, the ability to superimpose the map on to the space it represents, is provided in studies requiring children to duplicate on their own model space the location of a target object placed on the experimenter's model space (Laurendeau & Pinard, 1970; Piaget & Inhelder, 1967; Pufall & Shaw, 1973). While these studies do not involve inferences to large-scale spaces, they do supply information about the reference systems used to code locations at different points in development. In particular, by rotating one space 180° relative to the other, they have revealed that the pre-operational child often codes location egocentrically, as if no rotation had occurred. The question remains, however, whether this egocentrism is a pervasive predisposition which at this age would influence any space to space inference, or whether it is simply a by-product of the particular paradigm employed in these studies. In each case the two spaces are located adjacent to one another, presumably eliminating the possible confounding effects of memory deficits. Such visual proximity, however, may actually encourage the establishment of a misleading correspondence between the two maps on the basis of simple, straight-line projections from map to map, thereby precluding the formation of a mediating cognitive map free of any

particular perspective. In other words, a possible by-product of the juxtaposition of the maps may be the creation of a compelling perceptual array which lures the pre-operational child into ignoring rotation in favor of replicating the visual array as he sees it from his own perspective. Support for such a hypothesis comes both from studies of spatial perception itself (Feinberg & Laycock, 1964; McKinney, 1964) and from Piaget, who has repeatedly concluded that children during this stage of development have trouble dissociating their responses from the perceptual aspects of a situation. It follows, then, that the children's performance on mapping tasks might actually improve if the space and the map were not in close proximity to one another.

In response to the major issues discussed above, the present study was designed (a) to gain insight into the development of symbolic processes in general; (b) to augment the Blaut et al. study by providing information about the development of children's ability to infer information from a 2-dimensional map to the 3-dimensional, large-scale space it represents; and (c) to test the hypothesis that egocentrism in map-like tasks is a result of the pre-operational child's tendency to be overwhelmed by the visual array presented by map and space in close proximity to one another. Specifically, 3-, 4-, and 5-year-old children were required to find a hidden toy whose location was indicated on a 2-dimensional map of a 3-dimensional room. This procedure was carried out for each subject under five conditions which were combinations of two variables: the positioning of the map either inside or outside the room, and the alignment of the map relative to the room (aligned, rotated 180°, vertically aligned).

Method

Subjects

The original sample of subjects included 60 children (22 3-year-olds, 28 4-year-olds, and 10 5-year-olds) from two middle-class suburban nursery schools. Of this original sample 46 passed a pretest, to be described below, and were allowed to complete the experiment. These 46 children included 12 3-year-olds (6 males and 6 females), 24 4-year-olds (12 males and 12 females), and 10 5-year-olds (4 males and 6 females).

Apparatus

The major piece of apparatus consisted of a 12 x 12 ft. (3.66 x 3.66m) collapsible room designed to enable control of the number and the saliency of the spatial cues available to the child. The room consisted of a wooden frame to which were attached four opaque curtains of white vinyl. The ceiling was made of white oilcloth and allowed diffused light to enter. Inside the room were four green boxes, 8 x 8 x 12 in. (.2 x .2 x .3m) in size, each positioned on the floor at the center of each wall. One corner of the curtains was open to function as a door; the other three corners were differentiated by a red box and two polyurethane foam shapes of different colors. There were two tables. One was positioned inside the room and was surrounded by four chairs, each with its back to one of the walls. The other was positioned outside of the room about 6 ft. (1.83m) from the door. It had two chairs, one for the child and one for the experimenter. (See Figure 1.) Finally, materials included a small toy elephant about 4 in. (.1m) in length and a two-dimensional schematic representation of the room on a 12 x 12 in. (.3 x .3m) piece of cardboard. This map contained every distinctive feature of the room drawn in cartoon form from a vertical rather than aerial perspective. It also

contained a separate representation of the toy elephant, with an adhesive backing, that could be repositioned on the map.

Insert Figure 1 about here

Procedure

For each subject the session began with a familiarization phase in which the child was seated at the inside table with the map and room perfectly aligned and asked to identify the pictures on the map and point to their referents. The experimenter then explained that the child was to use the pictures to find Peanut the elephant. In the conditions in which the map was located inside the room the child was asked to stand outside momentarily while the experimenter hid the elephant and designated the position on the map. When the experimenter said "Ready!" the child returned to his or her seat in the room, viewed the map, and went to find the elephant. In the conditions in which the map was placed outside the room, the experimenter entered the room without the child in order to hide the elephant and returned to designate its position on the map. The child viewed the map and then went inside to retrieve the elephant. Once the child entered the room he or she was not allowed to return to the map. In all cases the child was warned that the map might not be perfectly aligned with the room and to be very careful to choose the correct box. These basic procedures were repeated three times for all five conditions, a total of 15 trials per child.

Conditions. The first condition each child experienced was the 0°-Inside condition in which the map was placed on the inside table and perfectly aligned with the room. This condition served as a pretest since it was assumed that

a child who was unable to infer the correct location from the map under these simple circumstances would be incapable of establishing a map to room association in the more complicated conditions to come. Subjects failing this condition were not tested further. In the 0°-Outside condition the map was positioned on the outside table but still aligned with the room. In other words, the child's perspective of the map was the same as his or her perspective upon entering the room. In this case, due to the removal of the map from the room itself, direct perceptual matching was not possible and the child was forced to rely on a mediating cognitive representation. In the 180°-Outside condition the map was positioned on the outside table and also rotated 180° relative to the room. Consequently, in this condition the child was required not only to maintain a cognitive representation, but also to mentally rotate it to find the elephant. In the fourth condition, the 180°-Inside condition, the map was again positioned on the inside table but was rotated 180° relative to the room. In this case the presence of the map in the room enabled the child to forego the formation of a mediating cognitive representation, but did require the child to multiply relations in order to compensate for the rotation. Obviously, a child who shortcuts this compensation by resorting to direct isomorphic matching in this condition will end up choosing the incorrect box directly opposite the correct one. Finally, the fifth condition, the Vertical-Outside condition, involved having the child view the map outside the room with the experimenter holding the map vertically by one corner to eliminate any horizontal alignment with the room. The corner held at the top was the corner diagonally opposite the door; consequently, the child's view of the map, disregarding the planar differences, could be

interpreted as a close approximation of his or her view of the room upon entering (essentially a third 0^{o}, aligned condition). This condition was included in order to determine at what point in the development of map-reading a child acquires the flexibility necessary to perceive information presented in the vertical plane as isomorphic with spatial relations experienced in the horizontal plane. In other words, at what point does "up" become synonomous with "far away" and "down" with "close"?

Order. Since all subjects were tested in all conditions, it was necessary to counterbalance the order in which the conditions were experienced in order to control for practice effects. This was done with two exceptions: the 0^{o}-Inside condition, because of its role as a pretest, was experienced first by all subjects, and the Vertical-Outside condition was experienced last by all subjects. Subjects were randomly assigned to the six possible orders of the remaining three conditions.

Results

In each trial of each condition a subject had a choice of one of four boxes. In other words, there was one chance in four that he or she would pick the correct box by choosing randomly. In order to be certain that a child's success was not due to such chance guessing, the subject, to be scored successful, was required to correctly find the elephant on not just one but rather two of the three trials in a given condition. Use of this criterion dropped to .06 the probability that the child's success was due to random guessing.

Presented in Table 1 are the proportions of subjects at each age who were scored successful in each of the five conditions. As can be seen from the table several dramatic age changes occurred. First, in the simplest

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Insert Table 1 about here

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condition of all, the 0^{o}-Inside condition which functioned as a pretest, analyses revealed that significantly fewer 3-year-olds performed successfully than either 4-year-olds ($\chi^2(1) = 4.49$, $p < .025$) or 5-year-olds (Fisher exact probability test, $p = .01$). In other words, almost half of the original group of 3-year-olds, compared to none of the 5-year-olds, failed to pass the pretest and were eliminated from further testing. Second, the relatively high proportion of successful subjects (of those remaining) at all ages in the 0^{o}-Outside condition, indicates that if a subject could find the elephant when the map was aligned inside of the room, he or she could probably also do so when the map was aligned outside of the room. There were no significant age differences for this condition. Third, in both the rotation conditions, 180°-Outside and 180°-Inside, the 5-year-olds performed significantly better than either of the two younger groups (Fisher exact probability tests, $p < .005$ in all four cases). The 3- and 4-year-olds, however, did not differ from one another. Finally, the Vertical-Outside condition produced relatively high proportions of success at all ages and resulted in no significant age differences.

Data analyses were also conducted to determine whether some conditions were significantly more difficult than others at any of the three ages. Again, the pattern of differences is clear from Table 1. For the 3-year-olds, the 0^{o}-Outside condition resulted in a significantly larger proportion of successful responders than either the 180°-Outside condition (McNemar test,

$\chi^2(1)=7.1$, $p < .005$) or the 180°-Inside condition (McNemar test, $\chi^2(1) = 4.9$, $p < .025$). Performances in the latter two conditions did not differ significantly. This supremacy of the 0°-Outside condition over the 180° rotation conditions was also found for the 4-year-olds (180°-Outside: McNemar text, $\chi^2(1) = 14.06$, $p < .0005$; 180°-Inside: McNemar test, $\chi^2(1) = 13.07$, $p < .0005$). The 5-year-olds, in contrast, performed with equal ease under both rotated and non-rotated conditions. The same pattern of results was found in comparing the Vertical-Outside condition with the two 180° rotation conditions. For both the 3-year-olds and 4-year-olds the Vertical-Outside condition was significantly easier than both the 180°-Outside condition (3-year-olds: McNemar text, $\chi^2(1) = 4.2$, $p < .05$; 4-year-olds: McNemar test, $\chi^2(1) = 7.69$, $p < .01$) and the 180°-Inside condition (3-year-olds: McNemar test $\chi^2(1) = 3.2$, $p < .05$; 4-year-olds: McNemar test, $\chi^2(1) = 5.06$, $p < .025$). Once again there were no differences between these conditions for the 5-year-olds. There was also no difference between the 0°-Outside condition and the Vertical-Outside condition for any of the age groups.

The comparative ease with which all three ages handled the Vertical-Outside condition raises the question whether practice effects might have been operating. Perhaps the fact that this condition was the last condition experienced by all subjects accounts for its high proportion of successes. In order to determine whether this might be the explanation, performances for the three conditions whose order was counterbalanced were examined (0°-Outside, 180°-Outside, and 180°-Inside). The number of subjects performing successfully on the first condition experienced (whichever one that was)

was compared to the number performing successfully on the second and third conditions experienced, since, presumably, practice effects will increase the number of correct responders across succeeding trials. Presented in Table 2 are the results of this analysis. Clearly, the number of successes did not

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Insert Table 2 about here

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increase with succeeding trials for these three conditions. Indeed, the numbers are nearly identical for each trial. The absence of any practice effect here provides comfortable assurance that such effects alone probably cannot account for the large proportion of successes in the Vertical-Outside condition. The condition appears simply to be an easier map-reading situation for the 3- and 4-year-olds than the two 180° rotation conditions.

One of the major purposes of the experiment was to determine the order in which the map reading skills represented by each condition enter a child's repetroire. In order to help answer this question the patterns of success and failure for the individual subjects were evaluated. Presented in Table 3 are the nine patterns which occurred (out of 16 possible patterns) and the proportion of subjects at each age exhibiting each one. Several things are

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Insert Table 3 about here

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clear from this pattern data. First, the patterns of success and failure are not random. On the contrary, 64% of the subjects exhibited one of two patterns, as opposed to the 12% that would be expected by chance. Second, it is clear that the 0°-Outside condition was easier than the two 180° rotation conditions, only one subject performing to the contrary. Third, the data indicate quite

conclusively that when the type of rotation is held constant, the varying of the map's location (inside vs. outside) does not seem to affect the accuracy of performance. For example, of the 46 children who found the elephant in the 0°-Inside condition (the pretest), 41 were also able to do so in the 0°-Outside condition. Similarly, out of 46 subjects, 41 performed identically in the 180°-Outside and the 180°-Inside conditions. Of the 5 who did not, 2 passed the Outside but not the Inside condition, while 3 did the reverse. In other words, the hypothesis that merely removing the rotated map from the room itself would facilitate performance was not supported.

A fourth conclusion that can be drawn from Table 3 concerns the position of the Vertical-Outside condition relative to the other conditions. These within subject patterns indicate that this condition was somewhat more difficult than the 0°-Outside condition, but at the same time easier than either of the 180° rotation conditions. The evidence to support these conclusions includes the fact that 76% of those who passed the 0°-Outside condition also passed the Vertical-Outside condition compared to only 41% of this same group who passed either or both of the two rotation conditions. A Guttman scaling analysis indicated that these data did provide strong evidence in support of the suggested sequence.

Finally, the errors that the children made in the two rotation conditions were analyzed to determine what proportion were egocentric in nature. An egocentric error was defined to be the choice of the box directly opposite the correct box, a mistake which would automatically result from the child's ignoring the rotation of the map relative to the room. The analysis revealed that of the 30 unsuccessful subjects in the 180°-Inside condition, 28 (or 93%)

had made egocentric errors. In contrast, among the 31 unsuccessful subjects in the 180°-Outside condition, only 20 (or 65%) made egocentric errors. A Chi square test indicated this difference between the conditions was significant (Chi $(\chi^2(1) = 5.93, p < .01)$. In other words, there was a significantly greater likelihood of egocentric errors when the map was located inside the room. With the map outside the room, a nearly identical number of errors occurred, but these were not as often egocentric in nature.

Discussion

The purpose of the present experiment was to assess the ability of young children to make inferences about a three-dimensional space by using information supplied in a two-dimensional representation of that space--in other words, to read a map. The results of the experiment support several conclusions about this ability. First, the data from the 0°-Inside condition, the pretest, indicates that even under very simple conditions many 3-year-old children are unable to solve a map-reading problem. In terms of the three components discussed previously, the deficit in this case appears to be in the third component, the ability to superimpose the map on to the space it represents. It was only when they were required to actually find the elephant that they failed, not when questioned about the pictures on the map and their representative relationship to the objects in the room, the first of the three components. (Since in this condition the map was located in the room, the second component, the mediating mental representation, was not involved.) In contrast to the 3-year-olds, only a few 4-year-olds and no 5-year-olds failed this pretest condition. It appears, then, that the ages sampled in this study do include the period of onset of map-reading, at least in a rudimentary form.

These results, therefore, support the conclusions of Blaut et al. (1970) that children as young as 5 are capable of map-reading. More importantly, the present study has done so using a situation which comes much closer to true map-reading than the one used in that earlier study, and has extended the age downward to 3 years for some children. Rather than overestimating the map-reading abilities of young children, it appears that Blaut et al. were, if anything, underestimating their skills.

Although both the 4-year-olds and 5-year-olds were significantly more successful than the 3-year-olds in the 0°-Inside condition, these two groups did not continue to behave identically in subsequent conditions. Specifically, the data from the two 180° rotation conditions indicate that while 4-year-olds can make inferences from a map to a space, their accuracy is greatly influenced by the alignment of the map relative to that space. Both the 3- and 4-year-olds failed to compensate for the rotation in these conditions, and as a result chose, in most cases, the box directly across from the correct one. In other words, the present study demonstrates that the type of egocentrism found at these ages by researchers using model spaces (e.g., Davol & Hastings, 1967; Pufall & Shaw, 1973) also occurs in a true map-to-space paradigm.

Particularly interesting here is the fact that removing the map from the room did not facilitate performance in the case of the 180° rotation as had been hypothesized. The 3- and 4-year-olds performed just as poorly in the 180°-Outside condition as in the 180°-Inside condition, and in both cases the majority of errors were egocentric in nature. It would seem then, that children at these ages are quite likely to rely on the projection of directions indicated in their mental representation of the map, just as they do with the

map itself. In other words, requiring a mediating mental representation does not totally free the child from the "perceptual array" and thus increase flexibility. The child at these ages is as unable to perform a transformation on the mental representation as on the map itself.

But are we, perhaps, presuming too much by concluding that the problem is in manipulating the mental representation rather than in generating it in the first place? What evidence do we have that these two age groups are even capable of generating a mediating representation, the second of the three components presumed to be part of the map-reading process. The supporting evidence is provided by the high proportion of success for all age groups in the 0°-Outside condition. Once again, the position variable failed to affect performance. If a subject could perform successfully with the map aligned inside the room (the pretest), he or she, with few exceptions, could also do so with the map aligned outside the room. Success in this latter case indicates that the children were indeed capable of generating a mediating cognitive representation and that, therefore, the source of their failure in the 180°-Outside condition was their inability to perform a rotation transformation.

This pattern of results for the 3- and 4-year-olds is parallel to the findings of Hardwick, McIntyre, & Pick (1976) who also detected a period in development when the child is capable of generating but not mentally manipulating a cognitive map of a space. Using a triangulation task in which children were required to predict the location of objects from three station points with or without their view of the space obstructed, these researchers were able to construct maps approximating each child's mental representation of the inter-relationships among the objects. The evaluation of these maps indicated

that even the youngest subjects of the study, first graders, were capable of generating very accurate, coherent cognitive maps of the space, the school's library. Performance deteriorated, however, when the subjects were requested to imagine either the room rotated or themselves moving within the space. As in the present study, the type of errors predominating in these cases, particularly in the latter, were egocentric errors in which the children merely replicated their current view of the room without making any attempt to perform the requested transformation. Interestingly, shielding the children from viewing the room in these conditions decreased the proportion of egocentric responses. This result is consistent with the finding in the present study that removing the map from the room had its only significant impact in the fact that it decreased the proportion of errors that were egocentric in nature. Together these studies provide support for the hypothesis that spatial egocentrism is at least partially a result of the child's being overwhelmed by the perceptual array. However, it is also clear from these two studies that freeing the child from an egocentric perspective does not automatically enable him or her to perform an accurate mental rotation. A child can know what the correct answer is not without knowing what the correct answer is.

In contrast to the 3- and 4-year-olds, the 5-year-olds were able to compensate for the rotation of the map both inside and outside of the room. This decline in egocentrism between ages 4 and 5 seems surprising in view of the poor performance of the 6-year-olds in the Hardwick et al. (1976) study. The most likely explanation is that the mental rotation required in the

present study was more easily accomplished due to the simplicity of the space and the nature of the task. Rather than requiring the children to maintain the imagined rotation long enough to make a series of position predictions, all that was necessary in the present case was for the children to make one prediction--the location of the elephant. Furthermore, the child's choices in the present study were limited; the elephant was in one of only four possible locations and, consequently, accuracy had an all-or-none, non-parametric quality. In contrast, accuracy in the Hardwick et al. study was based upon a Euclidean judgment of absolute position, a dependent variable for which the probability of being totally accurate was much lower, particularly given the trouble children at these ages have with projective and Euclidean relationships (Piaget & Inhelder, 1967). Some support for this analysis of the differences between the two studies is provided in a study of the ability of preschool children to spontaneously coordinate perspectives of a large-scale space (Acredolo, 1977). As in the present study the dependent variable in this case was based upon a limited choice, and also as in the present study, the results indicated a decline in egocentrism between ages 4 and 5. In summary, the successful performance of the 5-year-olds in the rotation conditions is not as surprising as it might first appear.

Finally, the successful performance of so many of the children on the Vertical-Outside condition needs to be examined. In terms of the developmental sequence revealed in the data, this condition followed the two totally aligned conditions but preceded the two 180° rotation conditions. Clearly, this pattern of results indicates that children as young as three are capable of a degree of flexibility in their superimposition of map on to space. Specifically, it demonstrates the ability to interpret information presented in the vertical plane

as representative of relations in the horizontal plane. This transformation of perspective is apparently significantly easier to perform than the transformation required in the 180° rotation conditions. Such a conclusion is supported by the results of the study by Blaut et al. (1970). The children in that study demonstrated a similar flexibility in their ability to interpret an aerial photograph (horizontal perspective) as representing spatial relations among objects they had encountered only from a vertical perspective--trees, houses, cars, etc.

In summary, the results of the present study provide evidence that rudimentary map-reading is possible as early as 3 years of age. Moreover, the pattern of development from that point is consistent with an analysis of map-reading as divisible into at least three components. The first component, the ability to interpret the cartographic symbols as representative of objects in space, was demonstrated to be present in all the children. The second component, the ability to generate a mental representation of the map as an associative link to the space, was within the repertoire of half the 3-year-olds and almost all the 4- and 5-year-olds. This was evidenced by the fact that these children did as well when the map was aligned outside the room as when it was aligned inside. It was the third component, the ability to superimpose the map on the space, that underwent the most change across the age span studied. Specifically, the degree of alignment between the map and the space proved to be the important factor determining the success of the child's superimposition. Although half the 3-year-olds and all the 4- and 5-year-olds were able to deal with the aligned map, the two younger age groups were unable to compensate for the 180° rotation, making their choice from an egocentric perspective in the majority of cases. The ability to switch freely between vertical and horizontal planes while map-

reading marked an intermediate point in the developmental sequence. In each case the increased flexibility of the child's approach to the map-space relationship reflected the development in the child of the ability to ignore illusions presented in the perceptual array and apply appropriate logical operations to the stimuli. In this sense, the developmental history of this third component was revealed to mirror changes that characterize spatial development in general.

Reference Note

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Footnotes

A portion of this study was presented at the Society for Research in Child Development Meeting, New Orleans, March 1977.

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Table 1

Proportion of Subjects at Three Ages Performing Successfully in Each of 5 Experimental Conditions

Age	Condition				
	0° Inside	0° Outside	180° Inside	180° Outside	Vertical Outside
3 years	[illegible]	.75	.08	.00	.67
4 years	.86	.92	.25	.25	.77
5 years	1.00	1.00	.80	.90	.80

Note. Subjects not performing correctly in the 0° Inside condition were not tested in the remaining conditions and are therefore not included in the remaining columns.

Table 2

Proportion of Subjects at Each Age Performing Successfully on Each Subsequent Trial Experienced (Regardless of the Condition Involved)

Age	Trial		
	1st	2nd	3rd
3 years	.33	.33	.17
4 years	.46	.50	.50
5 years	.90	.90	.90

Table 3

Proportion of Subjects at Each Age Exhibiting Particular Patterns of Success (+) and Failure (-) Across 4 Experimental Conditions

AGES			CONDITIONS			
3 years (N=12)	4 years (N=24)	5 years (N=10)	0° Outside	Vertical Outside	180° Inside	180° Outside
.00	.17	.60	+	+	+	+
.00	.04	.10	+	+	-	+
.42	.46	.10	+	+	-	-
.17	.08	.00	+	-	-	-
.00	.04	.20	+	-	+	+
.00	.08	.00	+	-	+	-
.08	.00	.00	-	+	+	-
.00	.04	.00	-	+	-	-
.16	.00	.00	-	-	-	-
.16	.04	.00	+	Not tested	-	-
.00	.04	.00	-	Not tested	-	-

Note. The table includes at the bottom the performance of 4 Subjects who tired of the experiment before completing the Nonaligned-Outside condition. All comparisons of the other 3 conditions mentioned in the text include the data from these subjects.

Figure Caption

Figure 1. Experimental Space and Equipment.

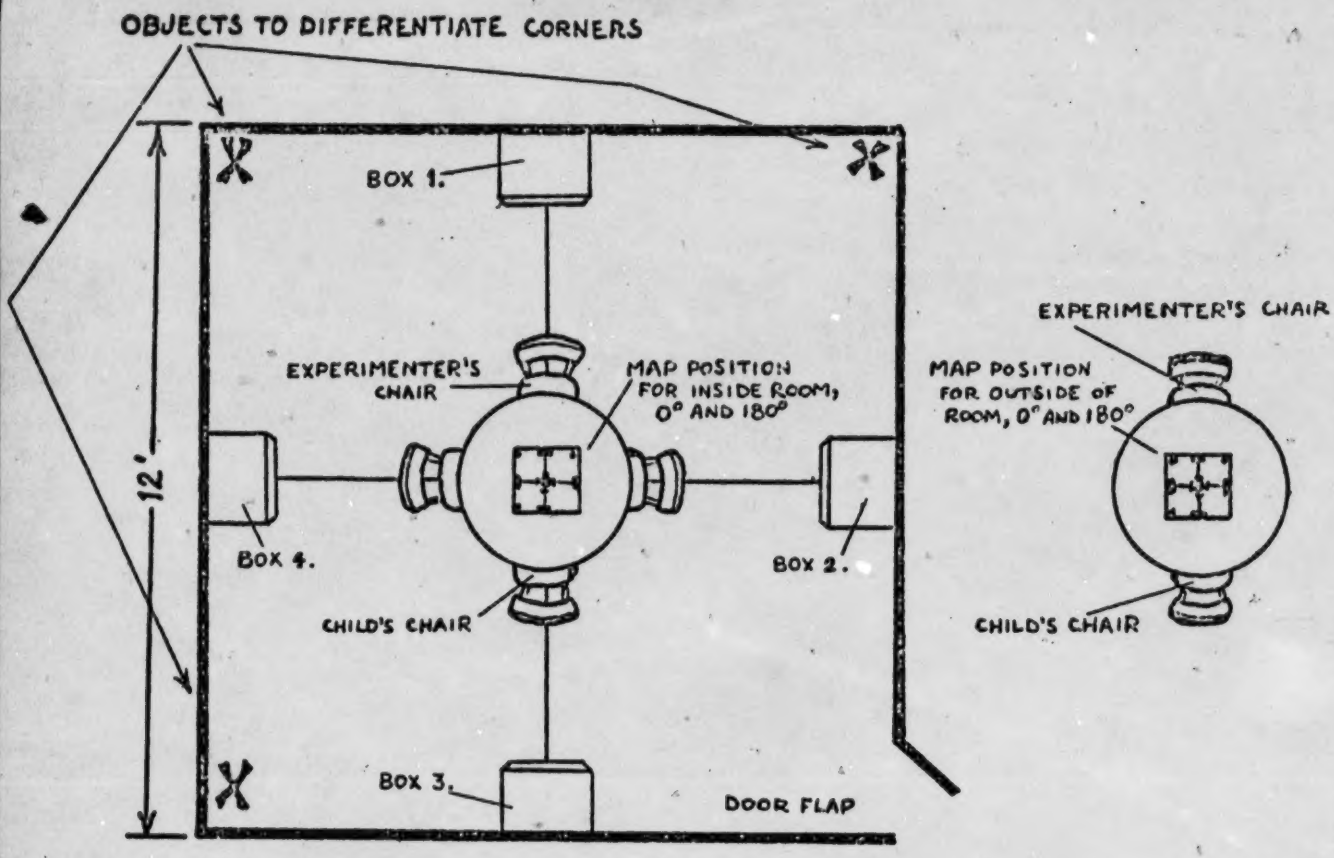

Figure 1: Experimental Room and Apparatus